This covers details of using calculating hue angles for color tolerancing such as using CMC DE to quantify the color difference between two samples in a way that correlates to human perceptibility ([see the formula here under the "CMC l:c (1984)" heading](https://en.wikipedia.org/wiki/Color_difference) or see [ASTM D2244-16](https://www.astm.org/e0308-22.html)). Such color tolerancing is critical to quality control for colored products and for assessing efficacy of cleaning products. In a sample dataset, the second set of graph labels shows the needed hue angles for a set a, b-color measurements mocked up to all have a Chroma (e.g. radius) equal to 10. See ATAN\_Check.xlsx in this Github repository.

<ATAN\_1.png>

A graph with lines and numbers

Description automatically generated

Starting with CIELAB color measurement data means being able to convert between rectangular x, y (a-color and b-color) and polar r, H (e.g. Chroma, C, and Hue angle, h) coordinates. No problem, right? That’s junior high math class stuff. An initial, [and stay tuned, incorrect], thought is that an Excel data entry template could utilize the built-in ATAN function to compute **h** as arctangent of **b/a** –with the [color science reminder](https://en.wikipedia.org/wiki/CIELAB_color_space) that **a-color** is red-to-green and **b-color** is blue-to-yellow and, when converted to polar coordinates, the radius or Chroma, C, is the intensity of the color and h is the hue or what normal humans would call the tone, shade or tint such as red, green, yellow and so on.

Per the ATAN Column C below, that function only returns results as first and fourth quadrant angles from -90 to +90 degrees and with mathematical #DIV/0! unpleasantness at the extremes where a-color is zero. We don’t get the required 0 to 360 degree hue angles. If you are unfamiliar with Excel’s “@” notation in these formulas, see the note at the end.

<ATAN\_2.png>

A screenshot of a spreadsheet

Description automatically generated

We get past this situation with Excel’s ATAN2 function. Historically, what could jokingly be called “ATAN deuce” probably represents Microsoft recognizing ATAN’s limitations and [almost] correcting it. Column D above and the first labels on the graph’s datapoints shows ATAN2 outputs for our test dataset.

ATAN2 results range from -180 to +180 degrees with no errors when a-color (aka x axis value) is zero. That’s better, but still not 0 to 360 degrees. For that, we add a conditional correction in the ATAN2\_mod (Column E) values. These are the second set of labels on the graph datapoints.

<ATAN\_3.png>

A screenshot of a computer

Description automatically generated

Note on Excel “@” Notation for Referring to Named Ranges

Our mockup file’s formulas use the modeling best practice of naming columns A and B “a\_meas” and “b\_meas”, respectively and using what Microsoft calls [“implicit intersection” with the “@” symbol](https://support.microsoft.com/en-us/office/implicit-intersection-operator-ce3be07b-0101-4450-a24e-c1c999be2b34#:~:text=The%20%40%20symbol%20is%20already%20used,same%20row%20from%20%5BColumn1%5D.) preceding the names in the formula. The “@” says to return the row’s value from the named column, and this is a best practice for creating easy-to-understand formulas (e.g. compare symbolic “@b\_meas/@a\_meas” here to classic cell reference syntax like “B4/A4”).